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The Relations between Spatial Structure and Land Price

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Abstract**—**Land price contains the comprehensive characteristics of urban space, representing the social and economic features of the city. Accordingly, land price can be utilized as an indicator, which can identify the changes of spatial structure and socioeconomic variations caused by urban development. This study attempted to explore the changes in land price by a new road construction. Methodologically, it adopted Space Syntax, which can interpret urban spatial structure comprehensively, to identify the relationship between the forms of road networks and land price. The result of the regression analysis showed the 'integration index' of Space Syntax is statistically significant and has a strong correlation with land price. If the integration value is high, land price increases proportionally. Subsequently, using regression equation, it tried to predict the land price changes of each of the lots surrounding the roads that are newly opened. The research methods or study results have the advantage of predicting the changes in land price in an easy way. In addition, it will contribute to planners and project managers to establish relevant polices and smoothing urban regeneration projects through enhancing residents' understanding by providing possible results and advantages in their land price before the execution of urban regeneration and development projects.

Keywords**—**Space syntax, urban regeneration, spatial structure, official land price.

I. INTRODUCTION

A. Backgrounds and Purpose

LAND price represents not only the comprehensive characteristics of urban space, but also the social and economic features of a city. Land price has been utilized frequently in the analysis of urban spatial structure, land development and the housing market as an indicator to identify the socioeconomic phenomenon of the city. Meanwhile, urban regeneration projects that require active participation of residents have been widely undertaken around the nation in Korea. It is obvious that residents are sensitive to the changes of their property's value. Being able to provide the information to the residents in advance by predicting the changes of land price will enhance their understanding on urban regeneration projects. People will naturally participate in their interested fields and will be more active if they have some knowledge of the project. At this point, there are some problems to be considered. Because the impact factors that are related with determining the land price are diverse and complicated, it needs deliberate calibration of land values of all the lots within the project area. Though Korea has a system that assesses the 'Official Land Price (OLP)' of the every lot in the nation-wide area and discloses them every year, it is difficult to simulate with ease the changes of land price caused by urban development. Because the calibration process of OLP requires detailed changing data, for instance the variation of road width, the shape of lot's boundary etc., and considerable amount of costs for the assessment, it is difficult to simulate various development scenarios which are likely to occur. In this regard, this study aims to develop a method which can calculate the variations of land price according to the changes of the physical conditions of the urban make up caused by urban development such as a new road construction. In terms of study methodology, it applies Space Syntax, which can interpret the macro urban spatial structure, suggested by Bill Hillier to identify the relationship between urban spatial structure and land price approaching from the macro district level instead of the micro lot level [1], [2].

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B. Study Scope and Method

The study area is Jinju City, Korea, which is a local medium-sized city in Korea. To identify spatial structure based on the road networks in study areas, Space Syntax was applied. Following Space Syntax theory, three indicators; 'Integration', 'Control', and 'Connectivity' are calculated by the each axes (roads). Then, this study attempts to analyze the relationship between the morphological feature of the road network and the land price using regression analysis. Subsequently, it simulates several possible scenarios of new road construction to calculate new three Space Syntax indictors in the relevant areas. At simulation stage, by inputting the modified new values of Space Syntax indicators as independent variables into the regression equation produced earlier, the new land price of the lots adjacent to each new road can be obtained.

II. RELATED STUDIES

This study examined existing studies which are divided into three parts; first, the studies exploring the relationship between the changes in urban spatial structure and land price, second, the analysis of urban spatial structure by using Space Syntax, third, studies dealing with both land price and Space Syntax. Among the first case studies, No et al. investigated the relationship between the changes of land price and urban spatial structure in Jinju City, Korea [3]. As a methodology, it approached from microscopic spatial level instead of macro entire city level and analyzed the relations of them by land use zonings. They divided Jinju City into several areas from 1990 to 2015 and suggested the desirable planning directions of the city.

Oh is one of suggestive research cases analyzing urban spatial structure by applying Space Syntax. In this case, the characteristics of urban spatial structure were investigated using GIS and the correlation between the urban spatial structure and the distribution of commercial facilities around the road networks were analyzed in Anyang City, Korea, where a new town, Pyeonchon, was built in the 1990s [4]. The authors explored the spatial shift of the city center.

In respect to the spatial boundary, the existing studies analyzed the limited extent in a city. However, Lee and Lee conducted an objective and quantitative analysis combining qualitative analysis of the chronological statistical data and Space Syntax within a whole the city area [5]. In addition, it also analyzed the effect of the urban expansion to spatial structure.

Moon and Cho explored the relationship between the morphological shape of road networks and the crime occurrence using real crime data. They built an agent-based model in a computer virtual space and simulated the crime occurrence using several scenarios of new road construction [6]. Lim et al. attempted to analyze the correlation between human behavior and spatial structure. They found the impact factors of the spatial structure which are related with land price by using Space Syntax [7].

Lee and Jang compared the urban spatial structure of 1990, when land development projects were not initiated, with 2007 when the projects were completed in Wonju City, Korea to analyze the relationship between the spatial shift of the city center and changes of land price [8].

As shown above, several studies exploring the variations of land price and Space Syntax have been conducted. However, the cases that have dealt the land price using Space Syntax are relatively rare, especially in the area of urban regeneration. This study intends to develop a regression model to predict land price using Space Syntax. Simulating the various road construction scenarios and predicting land prices, this study contributes to enhancing the understanding of residents and promoting smooth urban regeneration projects.

III. Case Study

A. Spatial Structure of Jinju City, Korea

Jinju City has around 340,000 populations and has grown as a central city in western Gyeongnam province. Almost the entire city center was destroyed during the Korean War (1950-1953), and the current urban spatial structure and land use was reshaped during the 1960~1980's urban development projects (Fig. 1).

To analyze the urban spatial structure focused on the road networks in Jinju City, an axial map was created as shown in Fig. 2. After that, the three indicators of Space Syntax, 'Connectivity', 'Control', and 'Integration' were calculated.

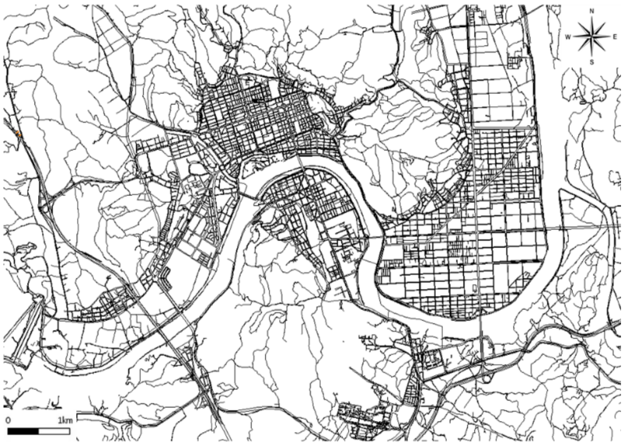


Fig. 1 Urban spatial structure and road networks of Jinju City

Fig. 2 Axial map of Jinju City

According to the Space Syntax theory, connectivity means the number of neighboring areas. Control represents its immediate accessibility from other areas and the control value becomes higher if one area is well used by other areas [9]. Integration is the average value of space numbers, which should be traversed to get access to all of the other spaces. This indicator expresses the relative depth of the space. A higher integration represents that the relevant space has a good accessibility within the entire space [10].

Among three indicators, a considerable number of research cases on the integration indicator were conducted. For instances, Choi and Kwon found that the integration index is closely related with the pedestrian volume in apartment complex [11]. Choi and Lee insisted crime occurs frequently in the area of large integration value because this area has more frequent and busier traffic [12]. As demonstrated above, three indicators of Space Syntax can be variously utilized to represent the characteristics of urban space and help to interpret social phenomenon.

B. The Relations between Land Price and Spatial Structure

To explore the relationship between land price and urban spatial structure, this study needs to select diverse sample areas that have typical land use and living environments. For these reasons, this study took seven administrative districts, as in Fig.

3. They are classified into two types; areas that were developed by urban planning, and those that formed naturally without any artificial intentions and systematic urban planning.

From locational context, sample areas were also selected differently; 'A' region shown in Fig. 3 is the stable residential area on the outskirt of the old town, while 'B' region is the area where detached houses, apartment complexes and old naturally-formed villages are developed. 'C' region is a residential area. In addition, region 'D' is the newly developed area, where the riverside green strip running alongside the Nam River is well developed. Region 'E' is the central area where financial companies and government offices are condensed, and region 'F' is the apartment concentrated area. This study analyzed the correlation between officially assessed land price (OLP) and spatial structure.

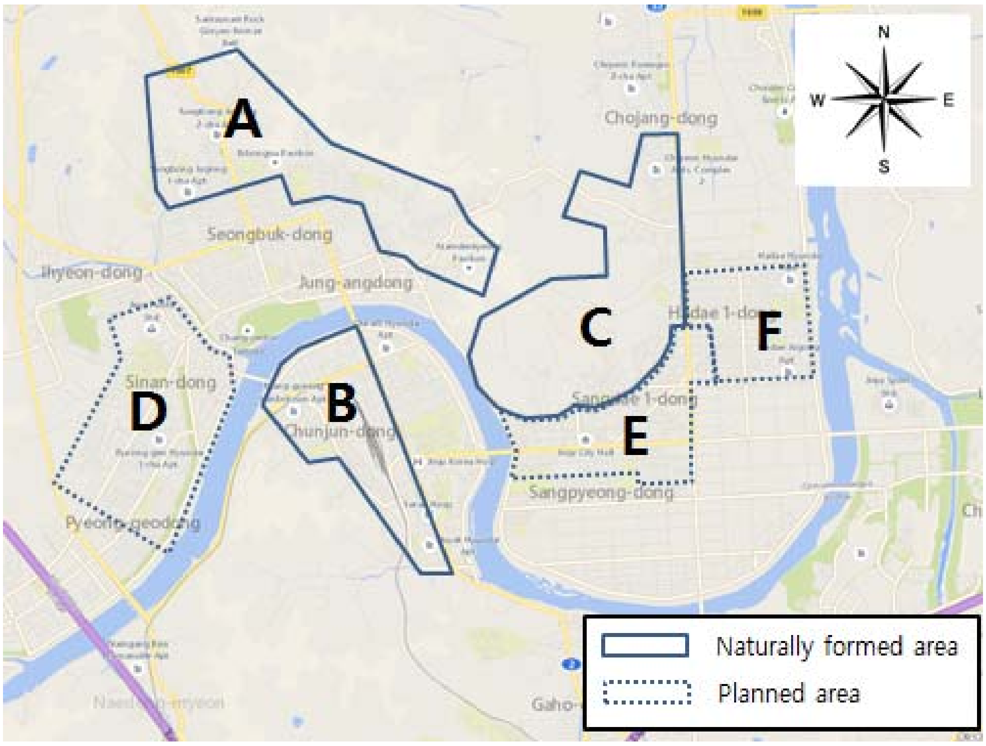


Fig. 3 Case study area

The number of standard lots in the sample area of which the officially assessed land prices (OLP) are disclosed by the government are shown in Table I.

TABLE I
NUMBER OF LOTS DESIGNATED AS OLP IN CASE STUDY AREA

Area type	Area(Dong)	No. of lots(ea.)
Planned area	Sangdae	119
	Hadae	82
	Shinan	61
Naturally formed area	Jungan	120
	Manggyeong, Juyak	58
	Sangdae, Hadae, Chojeon	43

Next, the values of the Space Syntax indicators of the roads that each standard lot is located are also calculated and listed in Table II. Then, regression analysis was conducted inputting the OLP of the standard lot was set as a dependent variable and the values of the three indicators produced by Space Syntax as independent variables. The results in Table II demonstrate that integration is statistically significant in both the planned-areas and naturally-formed areas.

TABLE II
CORRELATION BETWEEN SPACE SYNTAX AND OLP

Division	Area(Dong)	Connectivity	Control	Integration
Planned area	Sangdae	○*(0.58)**	○(0.50)	○(0.51)
	Hadae	X(0.77)	X(0.71)	○(0.76)
	Shinan	○(0.82)	X(0.75)	○(0.59)
Naturally formed area	Jungan	X(0.66)	X(0.59)	○(0.71)
	Manggyeong	○(0.82)	X(0.69)	○(0.76)
	Juyak	X(0.57)	X(0.52)	○(0.64)

* ○: significant at p<0.1, ** ( ): correlation coefficient.

Therefore, it can be concluded that if the value of integration becomes larger, land price gets proportionally higher, showing a high explanatory power of the regression equation, 0.57. Applying this regression model, we can predict the variations of land price caused by the changes in spatial structure, such as new road construction.

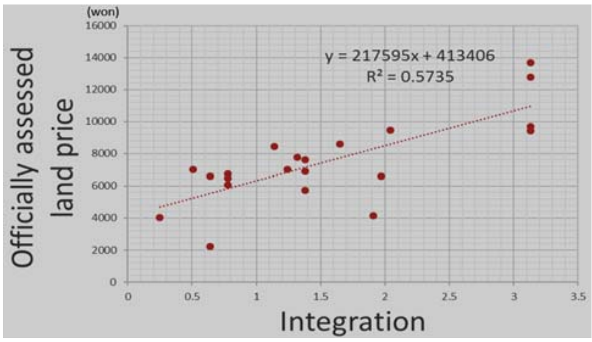
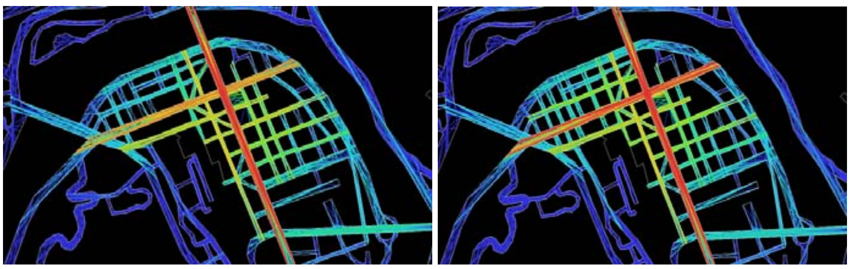


Fig. 4 Correlation between integration index and OLP

C. Simulations

The regression model established in the previous chapter was applied to the experimental area, Gangnam-dong, where the second stage of regeneration projects has been undertaken. By the public planning and investment, the environmental improvement projects such as opening new roads, building parks and parking lots have been progressed in this area. The red lots in Fig. 5 are the standard lots of which the OLP are estimated by government. The double red line represents new roads for the simulations, which had been temporally established for the experiment. In this study, we attempt to predict the changes of land price in the case area as a result of opening five new roads.

Fig. 5 Simulation area and roads that are established for experiments



(A) (B)

Fig. 6 Changes in the value of integration index

Fig. 6 shows the changes in spatial structure before and after the roads opening. There were no significant changes in the entire spatial structure. However, the colors of new roads had been changed from blue and greenish blue in Fig. 6 (A), which means a lower value in integration, into greenish blue and red in Fig. 6 (B). This represents the increase of integration value by the new roads.

The experimental OLP of the standard lots can be calculated by the regression equation obtained in the previous chapter to be shown in Table III. Comparing the land price before and after the road establishment, OLP became higher in some lots, while some became lower, contrary to expectations. As shown in Fig. 7, land price was dropped in the area where shopping buildings are located. The reasons are thought to be that these lots are facing main roads and have ease of accessibility, but the existing land price was already reflected highly because these lots are designated for commercial land use. However, the results showed that the land prices of other lots facing the new roads are increasing. As a result, the establishment of new roads in this area is expected to raise the land price by 11.8% on average.

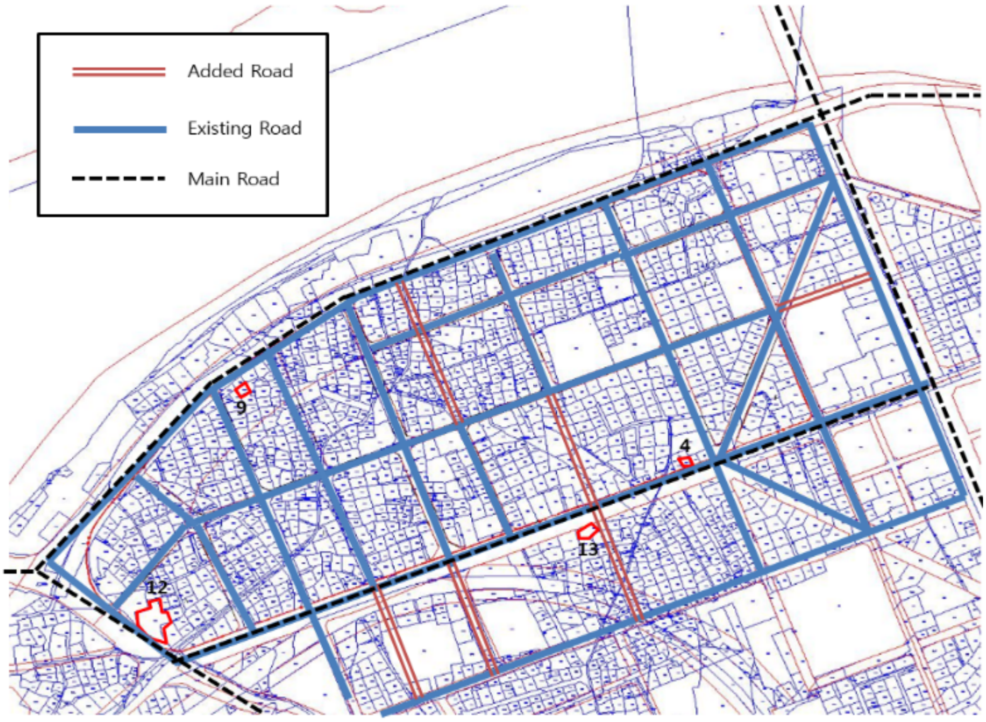


Fig. 7 Overestimated lots of OLP in study area and roads randomly established for experiments

TABLE III
VARIATIONS IN OLP IN STUDY AREA

Lot ID.	Current prices (won/m2)	Predicting prices (won/m2)	Rate of change (%)
1	861,000	910,597	+5.7
2	701,000	862,466	+23.0
3	660,000	914,972	+38.6
4	1,370,000	1,015,610	-25.8
5	943,000	1,015,610	+7.6
6	649,000	722,449	+11.3
7	969,000	1,015,610	+4.8
8	660,000	862,466	+30.6
9	778,000	713,698	-8.2
10	608,000	722,449	+18.8
11	675,000	722,449	+7.0
12	948,000	779,331	-17.7
13	1,280,000	1,015,610	-20.6
14	763,000	998,107	+30.8
15	572,000	979,509	+71.2
Average rate of change(%)			11.8

IV. CONCLUSIONS

In general, people are sensitive to the changes in the value of their properties. Since urban development and regeneration projects brings about the changes in spatial structure and directly affects land prices, people pay careful attention to the changing aspects around their properties. Because it is important to seek understanding and the participation of residents in the process of urban regeneration projects, it is crucial to provide them with scientific information regarding the changes in land price by the projects. However, it is not easy to predict land prices and costs if the area becomes wider. It requires a more convenient and persuasive way to simulate the variations of land prices. This study adopted Space Syntax and three indicators of Space Syntax were calculated; connectivity, control, and integration. The three indicators and OLPs of existing sample areas were input into regression analysis. The study results demonstrate that integration was the most highly correlated with the land price. The higher integration becomes, the higher land price increases.

After obtaining the regression equation between integration and land price, the effects on land prices by the opening new roads in the case region was simulated. The study results revealed that the changes in land price could be estimated by the analysis of Space Syntax in easy way, rather than the complicated and time-consuming OLP calculation system in Korea. The new method proposed in this study could be utilized in the urban regeneration field to enhance the understanding and participation of the residents and accelerate the project process. However, this study has some limitations. The regression model is too simple to reflect the complicated mechanism of land price. It is needed to develop a more deliberated model consisting of decisive variables such as land use and distance from main urban infrastructure and facilities etc. Nonetheless, this study is meaningful in that it is possible to identify changes in land price relatively easy way at the macro level of the district unit by using Space Syntax, even though it could not identify the land price up to the micro level of the lot unit.

Acknowledgment

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